WATER QUALITY STATUS OF RIVER YAMUNA TRAVERSING THE HIMALAYAN AND UPPER SEGMENT

SYNOPSIS OF THE THESIS

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DECLARATION

I hereby declare that the dissertation synopsis entitled: **WATER QUALITY STATUS OF RIVER YAMUNA TRAVERSING THE HIMALAYAN AND UPPER SEGMENT**, to be submitted for the partial fulfillment of degree of Philosophy in Chemistry is my original work and the dissertation has not formed the basis for award of any degree/diploma/associateship or fellowship of similar other titles. It has not been submitted to any other University or Institution for the award of any other degree or diploma.

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1. Introduction

Water is an essential part of our life. Although water covers 71% of earth surface mostly in Sea and Ocean, only 1% of water resource is available as fresh water. W.H. Auden once said:' **Thousands have lived without love, not one without water**'. Problems related to water pollution is as urgent as any other kind of pollution (Zaytseva, M.V, 2007). Today water pollution is a major global problem. Water quality holds high significance since it is directly correlated with human health, protection of the environment, plant growth and sustainable development (Arain *et al.,*2008). Most of health issues that affect humans especially in developing countries like India can be linked to safe and wholesale water supply (Shyamala *et al.,* 2008). Our Country is breaking all records in increased water pollution levels, the reflection of which is seen in the sad sight of our rivers. According to Center for Science and Environment, around 80% pollution in rivers is due to untreated sewage, garbage and industrial discharge, that totals to over 3 billion liters of waste every day.

India has 14 major rivers and most of the activities related to cleaning and discarding are dependent on rivers (Sharma 2007*;* Kaushik *et al.,*2009). India ranks 120th among 122 countries in water quality index, says NITI AYOG. Almost 70 percent of India's surface water resource and an increasing percentage of its ground water resources are contaminated by organic, inorganic, biological and toxic pollutants.

India has 195 million hectares land under cultivation. 37% of this agricultural land is entirely dependent on irrigation, and rivers are a major source. Along with acting as a major source for irrigation, rivers provide livelihood to many people. Groundwater aquifers are also moved through river streams (Kamboj & Kamboj, 2019)

Still, 70% of water available in India is deemed as polluted. This is an alarming state. (Mehdi, 2007). When Rivers are so important for us, it becomes our prime duty to keep them clean, the responsibility that we shun away from.

We have progressed a lot on Industrialization. While this is good for our economy, there are a lot of side effects to deal with, an important one being the chemical and waste effluents that are released in the rivers without being treated. During the production, industries generate useless waste with 1 to 10% of parent chemical (CPCB 2004). The industrial effluents if not treated and

controlled can pollute and cause serious damage to groundwater resources (Olayinka, 2004)**.** Once the pollutants enter the water, it becomes difficult to clean them and in turn proves to be more expensive (Avnish & Saxena., 2010). It not only endangers the aquatic life but makes the water unfit even for bathing, forget drinking.

70% of Indian population lives in villages and nearly 60% of them live near rivers. A lot of their sewage (water waste from washing clothes, defecation) goes into rivers and pollutes them. Only 19.7% of rural and 70% of urban population has access to sanitation facilities (World Resource Institute 2000).

1.1 The Yamuna & Its Segments

India has ten major river systems among which Yamuna is the longest tributary of The Ganga (Negi, 1991). It emerges from Yamunotri glaciers at an elevation of 6387 meters in lower Himalayas. It flows from Uttarakhand, Himachal Pradesh to Haryana, further going through Delhi, Mathura and Agra. Yamuna connects with the river Ganga and Saraswati (in underground state) at Prayag, Allahabad after traversing about 1376 Kms. Many other tributaries like Hindon, Chambal, Sind, Betwa and Ken join river Yamuna in between this stretch (Jain, 2004).

The entire stretch of Yamuna River is divided into 5 segments (Naithani, 2015):

Segment	**Course covered**	**Length in km**
Himalayan Segment	Yamunotri – Tajewala Barrage	172
Upper segment	Tajewala Barrage – Wazirabad Barrage	224
Delhi Segment	Wazirabad Barrage – Okhla Barrage	22
Eutriphicated Segment	Okhla Barrage - Chambal Confluence	490
Diluted Segment	Chambal Confluence - Ganga Confluence	468
Total Length		**1,376**

River flowing in between Yamunotri and Tajewala is called Himalayan Segment. While the river remains relatively clean till it reaches Paonta Sahib, water waste and untreated industrial waste inflows into the Yamuna at various points till Tajewala.

Region between Tajewala to Wazirabad (Delhi) is the Upper Segment. There is a diversion of Yamuna water into two canals from Tajewala: Western Yamuna Canal (WYC) and the Eastern Yamuna Canal (EYC). Water from WYC goes to Haryana and EYC goes to Uttar Pradesh (UP). (Sakhuja & Sharma, 2016).

1.2 Pollution: -The Yamuna

Thanks to the rapid urbanization, industrialization and agriculture development together with callous approach of people towards water cleanliness, pollution levels in all rivers, especially Ganga and Yamuna have reached alarming levels, Ganga now being the 6th most polluted river in the world. The largest source of water pollution is untreated sewage (Sakhuja & Sharma, 2016). Out of 33,000 million litre of waste water generated every day from Class I and Class II cities (population >100,000, 50,000-100,000 respectively), only 30% is collected and treatment facility is available only for 20% (CPCB 2007).

Although Government of India has launched various projects for cleaning of rivers (like *Namami Gange* project in June 2014; cleaning of river Yamuna being a part of the project), a lot of work needs to be done.

Quality of water in a region depends on point and non-point sources of pollution (Nnane *et al.*, 2011). Point source is a specific source like industry effluents or treatment plants while nonpoint sources refer to urban issues like sewage, agriculture issues like pesticides (Spatial and seasonal characteristics of river water, H. Bu, 2014). Pollutants have been classified based on their mode of occurrence in physical, chemical and biological.

A healthy river should contain minimum 5 mg/L of Dissolved Oxygen and 3 mg/L of Biochemical Oxygen Demand. Fecal coliforms count should not exceed 500 per 100 ml water.

Water quality of Yamuna at most of the places has been categorized as Class E-(suitable only for industrial use, watering etc) (Anil. M, 2009 and Hindu *et al*., 2002).There are many points in the journey of Yamuna where water deterioration has happened. While the water quality started getting impacted from Paonta Sahib and Yamuna Nagar, heavy pollutant discharge in Delhi-Agra belt have further deteriorated it (Anil. M, 2009).

2. Literature Review

A lot of study has been done on pollution level of Yamuna River, from its origin at Yamnotri to Allahabad where it meets other two rivers, The Ganga and Saraswati. Nivetha and Sangeetha in their work of 2020 analyzed the impact of industrial activities on water quality of various water bodies. A. K. Mishra in his research work done in 2010 describes the current situation from Yamuna Nagar, highlighting various sources of water pollution. Another research on upstream and downstream water quality of Yamuna Nagar focused on 16 Kms of area around Yamuna Nagar to measure various parameters like pH, hardness, alkalinity, BOD, COD etc and also found the presence of various viruses and bacteria like Salmonella group (typhoid) *Shigella* (Bacillary dysentery) *Mycobacterium* (tuberculosis and cholera which causes diseases like gastroenteritis, diarrhea, respiratory illness, heart diseases, liver diseases etc.) described by Sakhuja and Sharma in 2016. There are many researches done on pollution levels in the stretch of Delhi, Mathura, and Agra. Research by Darshan in 2004, Divya *et al.* in 2012 mention the current status of water quality in these areas and the water treatment facilities available. It clearly shows a major gap in amount of sewage generated and the treatment facilities. These researchers also depict the presence of heavy metals and their affects.

Evaluation done by Bhardwaj, *et. al.* in 2017 on their research show the presence of heavy metals in Delhi stretch from seven sample points. It shows that Fe (Iron) is the most abundant metal and Cd (Cadmium) is the least among all seven sampling sites. Setia, *et.al.* in 2020 also studied the impact of metal contamination in Sutlej river on human health.

Seasons also have a significant impact on various parameters. Bhardwaj and Gupta in their 2018 study show increased levels of various parameters like TDS, TSS, BOD, and COD during monsoon season. This increase is primarily because of the increased influx of agricultural chemicals, domestic and riverside waste through runoff process.

Yadan and Khandegar in their 2019 research analyzed physico-chemical and heavy metal pollution from different sites in and around Delhi and used multivariate techniques for assessing water quality.

Apart from Physico-Chemical characteristics studied in Delhi stretch, Mutyar *et. al.* in 2018 also analyzed the presence of 9 pharmaceutical active compounds in their research across seasons in National Capital Territory of Delhi.

Upadhyay and Chandrakala in 2017 described physico-chemical parameters of Yamuna in Delhi to calculate the Water Quality Index (WQI). Through this method, the influence of various parameters is analyzed in detail, their sum is substituted in a formula and WQI is obtained. Resultant gives the overall quality of water.

Focus of above studies was Yamuna in and around Delhi as a lot of human and material waste joins the river through drains. Research done by Mishra in 2010 at Yamuna Nagar also shows significant variations in parameters (high levels of Biological Oxygen Demand, Coliform and very low levels of Dissolved Oxygen. The gravity of situation in this belt has been understood by CPCB too, who in their analysis (Status of Water Quality in India, 2007) also say that the water quality of river Yamuna has deteriorated between Paonta Sahib and Hathnikund Barrage (Upstream of Tajewala) and Kalanaur (downstream of Yamuna Nagar).

While the above studies have been done on river Yamuna, there are lot many research works done on other important rivers in India. Gupta, *et. al.*in 2017 did a research on impact of seasonal variations in physico-chemical and biological parameters on water quality of Narmada river in Madhya Pradesh. Kumar, in 2018, did a simulation of Gomti River (Lucknow) future water quality using various mitigation strategies. Impact of faecal sludge on ground water and river water quality of Gomti river was analyzed by Singh, *et. al.* in 2020. Ghosh, *et. al.* in their research done on ‘Adi Ganga’ in 2019 show the impact of urban waste on surface and groundwater quality. Paul did an extensive research in 2017 across various cities to assess pollution by heavy metals in river Ganga. Dwivedi, *et. al.* did a study in 2018 on changes in pollutant levels of Ganga and potential health impact of consuming toxicant fishes from basin.

3. Aims and Objectives

Gone are the days when Yamuna used to be polluted only near Delhi. Heavy industrialization coupled with callous approach of people has led to degradation of water quality even in the cities nearing the foothills. As mentioned earlier, river water is lifeline not only for aquatic lives and animals, but also to the people living near riverbanks as a drinking water source and for cultivation of crops. Clean and pollution free water promotes the wellbeing of every living organism, and the opposite is also true.

Paonta Sahib and Yamuna Nagar are both industrial towns. Paonta Sahib (Himalayan segment) is manufacturing hub for medicines and Yamuna Nagar (Upper segment) is known for paper & sugar industry. Pollution in this stretch of 50 Kms can be attributed to various sources, viz. Industrial waste, Agricultural waste and Human waste.

Since these two segments are not free from pollution anymore (as was the case earlier), we plan to analyze the current state of pollution levels and recommend ways and means to improve the water quality.

Objectives

The objectives of present work are:

1. To analyze physico-chemical parameters that needs urgent attention for improving water quality of river Yamuna.
2. To evaluate the status of pollution level between Himalayan segment and Upper segment along with the selected heavy metals in the river water.
3. Assess the variations in the quality of water at each of sampling location and understand the impact of seasonal variations.
4. To correlate and analyze data using appropriate multivariate technique. Data will be analyzed by MS Excel and statistical software. Multivariate technique will be used to analyze the significant difference in the physico-chemical parameters between different stations and association among the parameters

4. Methodology

4.1 Criteria for selection of sampling sites:

Sampling sites were selected keeping in view of the objectives of the analysis. Sites prone to inflow of pollutants were decided after survey of the area.

Seven sampling sites selected:

1. Chakrata Road, Dhalipur (Uttarakhand)
2. Swarg Dham, Near Telephone Exchange, Paonta Sahib (Himachal Pradesh)
3. Bhuppur Road, Shamsherpur/Timli Range (Himachal Pradesh/Uttarakhand)
4. Bahral (End of Himalayan Segment)
5. Tajewala, Yamuna Nagar (Upper Segment)
6. Vishwakarma Mohalla, Yamuna Nagar (Upper Segment)
7. Old Hamida, Yamuna Nagar (Upper Segment)

4.2 Methods of Sample Collection

Water samples will be collected from seven sampling stations seasonally in a year during Pre-onsoon (April-June), Monsoon (July-September) and a Post-Monsoon (October- November) period for the analysis of water quality, decided by various parameters and presence of toxic metals in water. Each sample was collected in plastic sample bottles of 5 liters capacity with tightly sealed caps. The water samples were collected at about 20cm depth using dip and grab sampling method. Before collecting the samples all bottles must be soaked in 10%HCl for 24 hours and then thoroughly cleaned with Chromic acid mixture ($K_2Cr_2O_7$ + conc. H_2SO_4), rinsed several times with distilled water and then dried. Care must be taken not to keep any air bubble inside the bottle. Immediate analysis of some physical parameters will be done at sampling site. For the analysis of other parameters samples were brought to the laboratory and were preserved with conc. HNO_3 (3ml/l) and conc. HCl (0.5ml/200ml) solution.

4.3 Parameters Studied

Physico-chemical analysis will be carried out as per the Standard Methods devised by American Public Health Association (APHA) 2012. Below are the parameters to be studied during research.

Parameters	Method Used
Physical Parameters	
Temperature	Thermometer
Conductance	Digital Conductivity Meter
TDS	Titration Assembly Apparatus
TSS	Titration Assembly Apparatus
Turbidity	Digital Turbidity Meter
pH Level	Digital pH Meter
Carbonates	Titration (Alkalinity)
Bicarbonates	Titration (Alkalinity)
Chemical Parameters	
Total Hardness	EDTA Method
Na & K	Flame Photometer
D.O	Azide Modification
B.O.D	3 Day BOD Test
C.O.D	Closed Reflux (Titrimetric Method)
Chloride	Angentermetric Method
Flouride	SPADNS Method
Nitrate	UV Screening Method
Heavy Metals	
Pb, Hg, Cr, Cu, Cd, Zn, Mn, Al, Fe	Atomic Absorption Spectroscopy
Biological Parameters	
Fecal Coliform	Fecal Coliform Test
Total Coliform	Total Coliform Test

Water quality standard of various parameters as per BIS (Bureau of Indian Standards), 2012 is mentioned below.

Physico-Chemical Parameter	Recommended	Acceptable Limit	Permissible Limit (in absence of alternate source)
Conductance(µS/cm)	ICMR	300	
TDS (mg/L)	ICMR/BIS	500	2000
Turbidity (NTU)	ICMR/BIS	1	5
pH Level	ICMR/BIS	6.5-8.5	No Relaxation
Hardness (mg/L)	ICMR /BIS	200	600
Alkalinity (mg/L)	ICMR/BIS	200	600
Ca (mg/L)	BIS	75	200
Mg (mg/L)	ICMR	30	100
Chloride (mg/L)	BIS	250	1000
Flouride (mg/L)	BIS	1	1.5
Nitrate (µg/L)	BIS	45	No Relaxation

Water Quality Index (WQI): It is an important tool to determine the drinking water quality. It is as index that reflects the composite index of various water quality parameters.

Study will determine water quality index using National Sanitation Foundation-Water Quality Index (NSF-WQI) based on major water quality parameters.

WQI Value	Rating of Water Quality	Grading
0-25	Excellent	A
26-50	Good	B
51-75	Poor	C
76-100	Very Poor	D
Above 100	Unsuitable for Drinking	E

5. Thesis Plan

Chapter 1: Introduction

This chapter covers the global scenario of problem area in brief and explains the various reasons of deteriorating physico-chemical properties of water, in reference to the Himalayan and Upper Segments of river Yamuna.

Chapter 2: Literature Review

This chapter provides extensive review on the various aspects of water pollution. It talks about the basic objective of conducting this research and briefly touches various parameters to be studied for determining water quality.

Chapter 3: Research Methodology

This chapter explains the theoretical aspects of methodologies used in this study. Selection of sampling sites, sample collection, the frequency and the standard procedures followed in laboratory.

4: Result and Discussion

Here we discuss the test results of various physico-chemical parameters carried out by using standard processes and analyze data following statistical approach.

Chapter 5: Conclusion and Recommendation

This chapter draws inferences from results as shown in the previous chapter. It also recommends ways and means through which pollution levels can be reduced, thereby improving the water quality.

6. Importance of the Proposed Research

River water is the source of living for many, be it flora and fauna or humans. Pollution of river water has direct and indirect affect on the entire ecosystem. In reference to river Yamuna, pollution levels start increasing as we move ahead from the Himalayan segment to Upper segment.

Once the points of pollution generation are known and levels of physico-chemical parameters are understood, we can take a holistic approach towards reduction of water pollution.

As citizens of the country clean water is our right, but we also hold responsibility to maintain it. Aim of this research will therefore be to understand the current state of pollution levels at various sampling points, analyze them and suggest ways and means to achieve the national objective of clean Yamuna, Green Yamuna.

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